Fundamental Study on Effect of Fabrication Tolerance on Slip Strength of High Strength Bolted Friction Type Joint with Thick Plates

Toshikazu TAKAI
Graduate Student
Osaka City University
Osaka, Japan
takai@brdg.civil.eng.osaka-cu. ac.jp

Xue PENG
Civil Engineer
Katayama Stratech Corporation
Osaka, Japan
housetsu@katayama-st.co.jp

Takashi YAMAGUCHI
Professor
Osaka City University
Osaka, Japan
yamaguti@civil.eng.osaka-cu. ac.jp

Kiyonori YAMASHINA
Graduate Student
Osaka City University
Osaka, Japan
yamashina@brdg.civil.eng. osaka-cu.ac.jp

Summary

This study focuses on fabrication tolerance of high strength bolted friction type joint. The investigation of past researches and experimental and FEM analytical results provides statistical characteristics of fabrication variation related to strength of the joint. The characteristic value shows that the variation of the thickness of coating hardly affects the slip strength of the joint. Furthermore, the influence of other variations is evaluated by the FEM analysis. This paper cleared predominant factors of fabrication tolerances affects slip strength of the joint.

Keywords: Fabrication tolerance, Slip strength, High strength bolted friction type joint

1. Introduction

Many past researches and studies on the influence of the fabrication tolerances to the strength of high strength friction type joint has been carried out, for which joints consist of thin plates ($t \leq 50$ mm) and do not contain many bolts in a line. This study focuses on the joint with extremely thick plates (75 mm) and many bolts (12 bolts) in a line. The influence of the variation to slip strength of the joint is evaluated by FEM analysis.

2. Investigation of fabrication variation

Fabrication variations are obtained from investigations of past researches and studies. This study focuses on parameters related to strength of connected members and mechanical aspect of joints. The former parameters are thickness, width, yield point, Young's modulus, Poisson's ratio and initial deflection of the plates. The latter parameters are slip coefficient of joints, bolt pre-load and thickness of coating on connected surface.

The coefficient of variation (COV) of thickness and width of plate are small as 0.5%. However, the COV of yield point, Poisson's ratio and thickness of coating are large as 10%. And, the COV of Young's modulus, slip coefficient and bolt pre-load are also large as 5%.

3. Evaluation of influence of variation of coating

The influence of variation of coating to slip strength of joint is evaluated by results of the past experiment. The distribution of slip coefficients is shown in Fig. 1 and Table 1. Fig. 1 shows that the difference of the coefficients from 50 μm to 150 μm is small as the slope of regression line. So, the variation of thickness of coating within from 50 μm to 150 μm hardly affects to slip strength.

4. FEM model of influence of fabrication variation

FEM Analysis is calculated by Abaqus/Standard 6.9. Geometrical configurations of some analytical cases are shown in Fig. 2. Analytical cases are classified by combination of the number of bolts in a

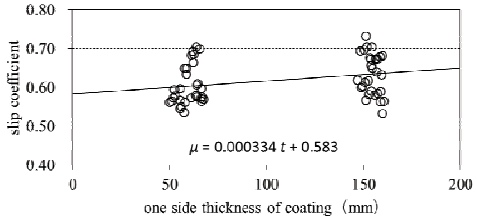
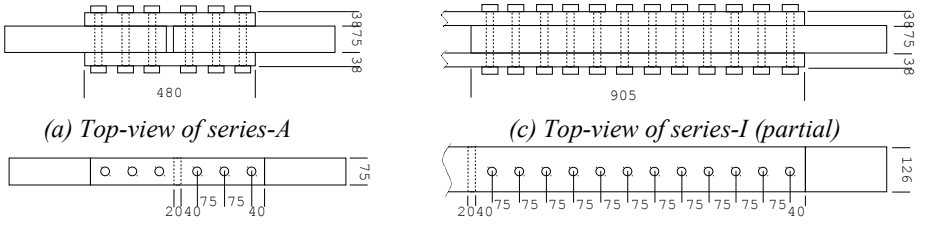


Fig. 1: Slip coefficient vs. thickness of coating

Table 1: Variation of coating

		target thickness of coating		
		50 μ m	150 μ m	total
the number of specimens		30	30	60
slip coefficient	mean m	0.603	0.635	0.619
thickness of coating (μm)	mean m	60.0	154.5	-
	SD σ	5.30	3.84	-
	COV	8.84%	2.48%	-



(a) Top-view of series-A *(c) Top-view of series-I (partial)*

(b) Side view of series-A *(d) Side-view of series-I (partial)*

Fig. 2: Examples of joint shape for analysis

line and slip/yield strength ratio β which is obtained as a slip strength divided by yield strength of connected plates as shown in Table 2. Series-A and G contains 3 bolts as not-long joint. And, series-C and I contains 12 bolts as long joint. β of the series-A and C equals to 0.66. And, that of the series-G and I equals 1.3.

Table 2: Analytical cases

		β = 0.66	β = 1.3
3 bolts	not-long joint	series-A	series-G
12 bolts	long joint	series-C	series-I

The joint consists of extremely thick plates. The grade of high strength bolt is F10T M22 whose diameter of bolt shank is 22 mm. Input values of variations of parameters are given to each FEM models according to the standard deviation obtained the investigation.

5. Results and discussion

In all series, the variation of slip coefficient μ and bolt pre-load N affects strongly to slip strength of the joint. Those affect over 2% of the strength. However, the influence of other parameters of series-A is less than 0.5%. These influences are very small.

In the case of β = 1.3, influence of yield point σ_y is large as over 1.3%. Plastic behaviour of connected and splice plate affects to slip behaviour before major slip. It is concluded that the variation of σ_y affects the slip strength strongly.

In the case of long joint, the influences of Young's modulus E are large as over 5%. The slip strength of the joints is determined by relative displacement. So, the variation of E, which relates to elastic elongation of connected and splice plates, affects slip strength strongly.

6. Concluding remarks

1) The variation of coating (inorganic zinc-rich paint) within from 50 μm to 150 μm hardly affects to slip strength of the joint.
2) Based on the statistical values of an investigation, FEM analysis has been carried out. In all series of analysis, variations of slip coefficient μ and bolt preload N affect strongly to slip strength of the joint.
3) In the cases of β = 1.3, the variation of yield point σ_y affect strongly to the strength. And, in the cases of long joint, the variation of Young's modulus E also affects strongly to slip strength.